PRECAST JOIST CONCRETE FLOOR

Construction Details

Facts About Precast Joist Concrete Floors

THIS manual is an assembly of information on the general characteristics, design and construction of low-cost, permanent floors built with premolded joists and job-placed reinforced concrete slabs.

The economy of this method of construction makes it suitable for residences and for other buildings having relatively light live loads. In no case should loads exceed safe superimposed load as given in Table I. Any desired type of floor finish—plain or colored concrete, tile, hardwood, linoleum, or carpeting—may be used.

The tables and details on design found in this manual are offered to assist architects and engineers in designing concrete joist floors. It is recommended that each job be designed and built under the supervision of a competent architect or structural engineer.

Aid to Modern Style and Beauty

"House of Tomorrow"

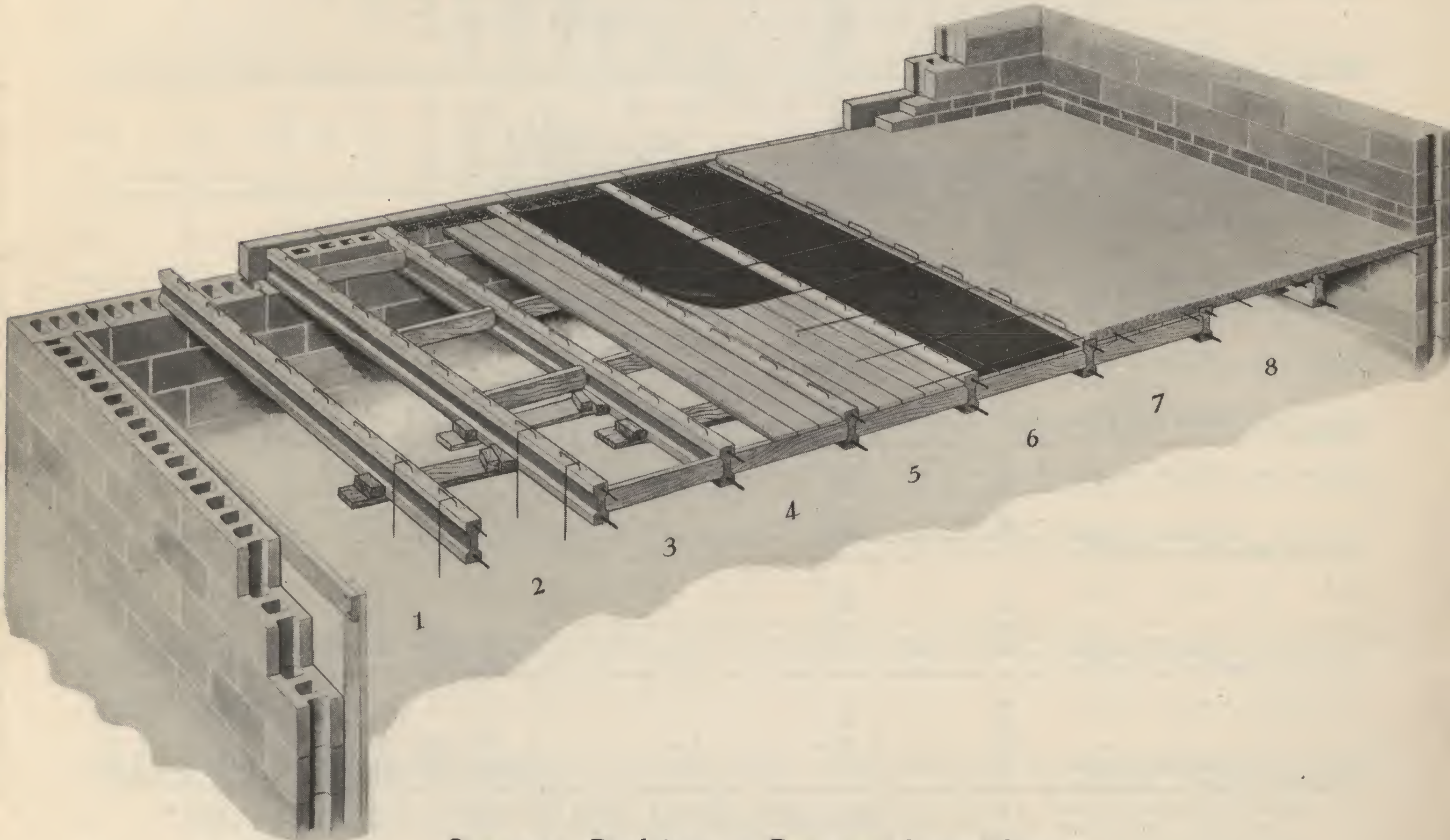
Omaha, Nebraska

This notable home has precast concrete joist floors and roof. Joists and under side of concrete floor slabs exposed and painted.

Practical

Economical

Easy to Handle



Steps in Building a Precast Joist Floor

1. Set precast concrete joists according to setting plan furnished by architect or manufacturer.

2. Place braces. Drive in wedges to line up and brace joists.

3. Set bridging between joists at supports (foundation walls). Insert spreaders. Place wire hangers for metal reinforcement, if plastered ceiling is specified.

4. Lay sheathing on spreaders. Box openings for service connections. Place small-mesh metal reinforcement over openings in concrete masonry units used as bridging.

5. Lay waterproof building paper, if smooth ceiling is required between joists. When wood floor finish is specified, place sleepers at right angles to joists.

6. Place two-way reinforcement for slab (¼-in. round bars), 10 in. on center, at right angles to joists; 18 in. on center, parallel to joists. If desired, large-mesh metal reinforcement of equivalent effective area may be substituted.

7. Place concrete, making slab 2 in. thick, when joist spacing is less than 27 in.; 2½ in., when spacing is 27 to 30 in.

8. Strip forms (braces, spreaders and sheathing) after concrete has moist-cured 5 to 7 days.

Design Table 1. SAFE SUPERIMPOSED LOADS FOR PRECAST JOIST CONCRETE FLOORS

Based on Joist Cross Sections shown on detail sheets JM10, and stirrup spacings shown in Design Table 2, Portland Cement Association, Joist Manual

Bottom Bar Size	Bottom Bar Area	Resisting Moment* In.-lb.	Maximum Shear* lb.	Joist spacing C.toC. In.	Slab Thick. In.	Wt.of Joist & Slab lb./sq.ft.	Safe Superimposed Load - lb./sq.ft.** (all loads except weight of joist and slab) Span in Feet: 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
						8-INCH JOIST - 1½" WEB THICKNESS															
5/8"ø	.31	44,500	1,610	20	2	34	146	113	88	68	52	40									
				24		32	117	89	68	52	40										
				27		32	101	77	58	43											
		47,200	1,720	30	2½	37	84	60	42												
Stirrup Spacing: Key No.							8-8 ←					→ 8-8									
3/4"ø	.44	62,600	1,920	20	2	34			139	112	90	72	58								
				24		32		140	111	89	70	56	44								
				27		32	141	122	96	75	59	46									
		66,400	2,040	30	2½	37	122	105	80	60	44										
Stirrup Spacing: Key No.							8-8	8-8	8-10 ←				→ 8-10								
7/8"ø	.60	84,600	1,905	20	2	34				139	126	112	93								
				24		32		140	124	111	101	88	72								
				27		32	137	121	108	96	87	76	61								
		90,000	2,025	30	2½	37	119	102	90	79	70	59	45								
Stirrup Spacing: Key No.							8-8	8-8	8-10 ←		→ 8-10	8-12	8-12								
						10-INCH-JOIST - 1½" WEB THICKNESS															
3/4"ø	.44	78,000	2,390	20	2	37					125	103	84	70	58	47					
				24		35				123	100	81	66	53	43						
				27		34			131	105	85	69	55	44							
		81,000	2,510	30	2½	39		145	114	90	70	54	41								
Stirrup Spacing: Key No.								10-8 ←								→ 10-8					
7/8"ø	.60	105,600	2,380	20	2	37							127	108	91	77	65				
				24		35					138	122	102	86	72	60	49				
				27		34			150	136	123	105	87	72	60	50	40				
		110,700	2,500	30	2½	39		144	128	114	102	90	72	58	46						
Stirrup Spacing: Key No.								10-10 ←		→ 10-10		10-12 ←					→ 10-12				
1"ø	.79	138,200	2,360	20	2	37							138	128	118	110	97				
				24		35				146	133	121	111	101	93	87	76				
				27		34			144	128	116	105	96	88	80	74	65				
		145,200	2,480	30	2½	39		141	125	111	99	89	81	73	65	60	51				
Stirrup Spacing: Key No.								10-12 ←					→ 10-12		10-14 ←		→ 10-14				
						12-INCH JOIST - 1¾" WEB THICKNESS															
3/4"ø	.44	93,500	3,340	20	2	44					150	123	101	84	69	56	45				
				24		41				150	121	100	82	67	54	43					
				27		39				129	105	86	69	56	45						
		97,500	3,480	30	2½	43			139	111	88	70	55	43							
Stirrup Spacing: Key No.									12-8 ←								→ 12-8				
7/8"ø	.60	126,500	3,320	20	2	44								133	112	95	80	68	58	48	
				24		41							128	108	92	76	64	53	44		
				27		39						133	111	93	77	65	54	44			
		132,000	3,460	30	2½	43					139	115	94	77	63	51	41				
Stirrup Spacing: Key No.											12-10 ←									→ 12-10	
1"ø	.79	166,000	3,310	20	2	44										139	120	104	90	78	68
				24		41									131	114	98	84	72	62	53
				27		39								133	114	97	83	71	61	52	43
		173,000	3,450	30	2½	43							138	117	99	83	69	57	48		
Stirrup Spacing: Key No.													12-14 ←								→ 12-14
1-1/8"ø	.99	208,000	3,290	20	2	44												142	126	111	98
				24		41									143	134	125	116	101	88	77
				27		39							145	133	125	116	107	99	87	76	65
		216,000	3,430	30	2½	43						140	128	117	108	100	92	85	72	61	52
Stirrup Spacing: Key No.												12-14 ←		→ 12-14	12-18 ←						→ 12-18

Safe superimposed loads include all loads except weight of slab and joists. Weight of floor finish, ceiling, partitions, etc. must be subtracted from values shown to obtain allowable live loads.

This construction is intended for relatively light live loads, such as schools and residential buildings.

Values to left of heavy vertical line are limited by shear, all others by bending moment.

Design based upon Code of American Concrete Institute with 3,000 lb. concrete and intermediate grade steel.

*Values for resisting moment and maximum shear are approximate and are based upon a T-beam section and j=7/8.

**Values for safe superimposed load are based upon a T-beam section and theoretical values of j. The allowable working stress for superimposed load is the difference between the maximum allowable working stress for steel and concrete and the dead load stress computed on the joist section independent of the slab.

Load capacity may be increased by: thickening webs at joist ends; hooking ends of tension steel to obtain special anchorage; supporting joists at mid-span until concrete slab hardens.

Spans of 20 feet or more should have 1 row of bridging at mid-span.

Design Table 2
J.M.

STIRRUP SPACINGS FOR PRECAST CONCRETE JOISTS

Based on Safe Superimposed Loads in Design Table 1, Portland Cement Association Joist Manual and the use of $\frac{1}{4}$ in. steel stirrups welded or hooked to upper and lower Bars.
Stirrup spacings Shown are for each end of the Joist.
Use additional stirrups approximately 18 in. on center through middle section of joist.

Bottom Bar Size in.	Span in Feet	Stirrup Key No. Joist Depth	Stirrup Key No. Single Stirrups ea. End	Stirrup Spacing from Each End of Joist, inches (scale 0–120)
8 in. Joist $1\frac{1}{4}$ and $1\frac{1}{2}$ Web Thickness				
5/8 3/4 or 7/8	10 - 15 10 - 11	(8 - 8)		3 6 6 6 6 6 6 6
3/4 7/8	12 - 17 12 - 14	(8 - 10)		3 6 6 6 6 6 6 6 6 6
7/8	15 - 17	(8 - 12)		3 6 6 6 6 6 6 6 6 6 6 6
10 in. Joist				
3/4	11 - 19	(10 - 8)		3 6 $7\frac{1}{2}$ 6 $7\frac{1}{2}$ 6 $7\frac{1}{2}$ 6
7/8	11 - 12	(10 - 10)		3 6 4 6 4 6 6 6 6 6
7/8 1	13 - 20 11 - 16	(10 - 12)		3 6 4 6 4 6 6 6 6 6 $7\frac{1}{2}$ 6
1	17 - 20	(10 - 14)		3 6 4 6 4 6 6 6 6 6 6 6 6 6
12 in. Joist				
3/4	12 - 20	(12 - 8)		3 6 9 6 9 6 9 6
7/8	14 - 23	(12 - 10)		3 6 4 6 6 6 9 6 9 6
1 1-1/8	17 - 24 15 - 17	(12 - 14)		3 6 2 6 2 6 2 6 2 6 9 6 9 6
1-1/8	18 - 24	(12 - 18)		3 6 2 6 2 6 2 6 2 6 9 6 9 6 9 6 9 6

Typical Specification for Precast Joist Concrete Floors

Precast Concrete Joists: Where shown on plans, contractor will install reinforced concrete floors employing precast concrete joists of approved manufacture. Contractor will submit joist framing details for architect's approval before work is started.

Joist Quality: Precast concrete joists to be manufactured of concrete having an average compressive strength of not less than 3000 pounds per square inch as measured by the strength of cylinders made from concrete at the time of manufacture and tested at an age of 28 days or when joists are delivered to the job.

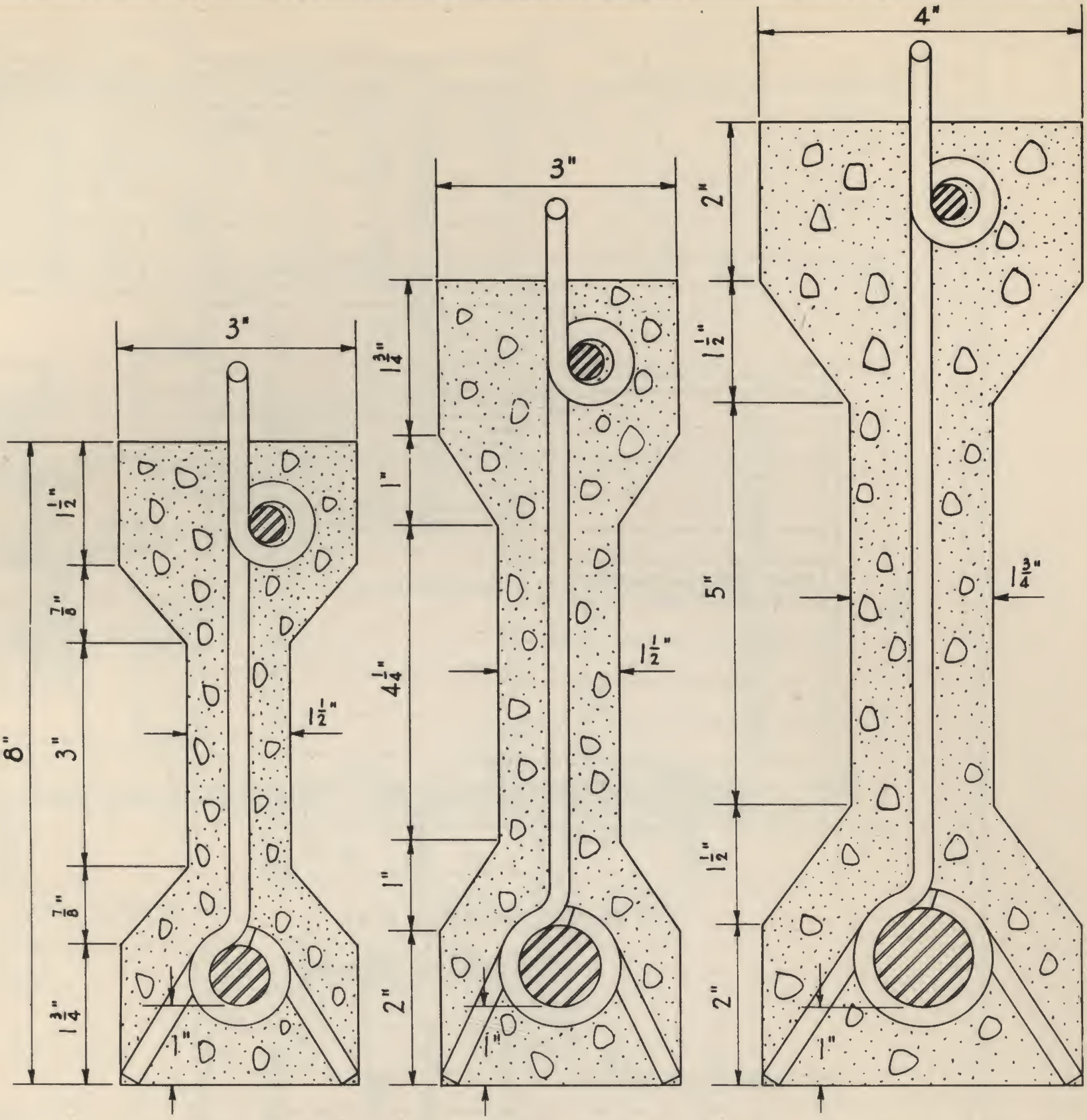
Reinforcement: Each precast concrete joist shall be reinforced with deformed bars in the upper and lower head connected by ¼-inch steel stirrups spaced as detailed on plans and effectively tied to the longitudinal reinforcing steel in an approved manner. Reinforcing steel shall meet American Society for Testing Materials specifications for "Concrete Reinforcement Bars."

Setting: Precast concrete joists shall be set in accordance with the setting plan and joist framing details. Bearing shall be made level and to proper grade with portland cement mortar. Joists shall be set to line and level with joist sides plumb.

Concrete Slab: Over the joists place a reinforced concrete slab of the thickness shown on plans. Joists are to be imbedded into concrete slab to a depth of ½ inch to ¾ inch. Effective bond shall be obtained between joists and slab. Concrete shall have an average compressive strength not less than 3000 lbs. per sq. in. at age of 28 days. Slab reinforcement to consist of ¼-inch round steel bars spaced as shown on plans or welded wire mesh of equivalent effective area may be used.

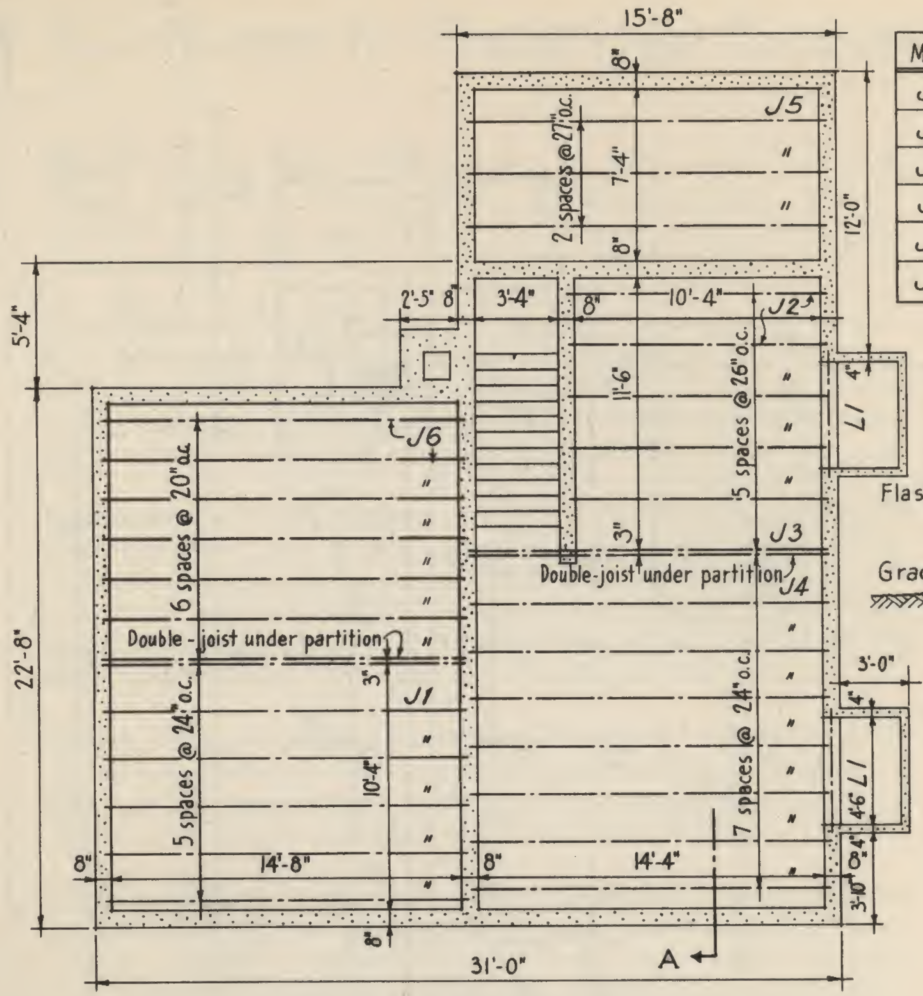
Openings for Mechanical Trades: Contractor will provide for openings in the slab required by mechanical trades. Note: Architect will determine in advance and specify where electrical conduit, water pipes, etc., will be placed in the slab, under the joists or through the joists. When pipes are incorporated in the concrete slab a minimum slab thickness of 2½ inches should be specified. If pipes are to be run through the joists, that condition should be specified so that openings may be cast in the joists at time of manufacture.

Floor Finish: (Specify and detail on plans type of construction and concrete surface finish to receive required floor finish. Colored concrete, terrazzo, tile, linoleum, rubber, carpet and hardwood floor surfacing materials are all adaptable to this type of concrete floor construction.) See Portland Cement Association publications "The Key to Firesafe Homes" and "Reinforced Concrete Floors for Residences."

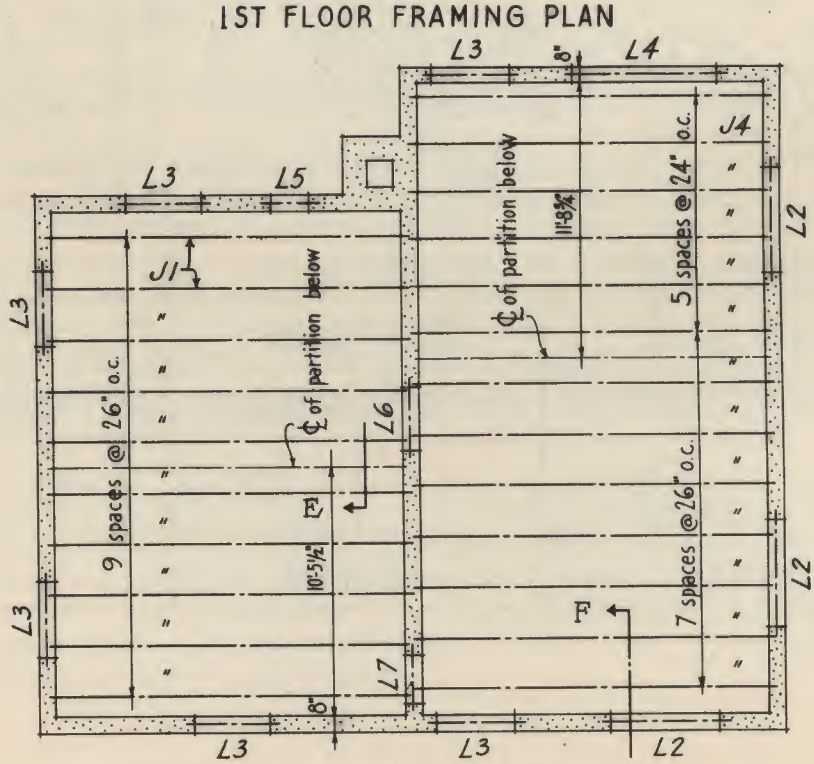


	8 INCH JOIST		10 INCH JOIST		12 INCH JOIST	
SECTIONAL AREA	18.2 SQ. IN.		22.1 SQ. IN.		33.4 SQ. IN.	
AGGREGATE	LIGHTWEIGHT	ORDINARY WT.	LIGHTWEIGHT	ORDINARY WT.	LIGHTWEIGHT	ORDINARY WT.
AVERAGE WT. OF JOIST PER LIN. FT.	14	19	17	23	26	35
MAXIMUM SPAN	16 FEET		20 FEET		24 FEET	

PRECAST CONCRETE JOIST CROSS SECTIONS



1ST FLOOR FRAMING PLAN

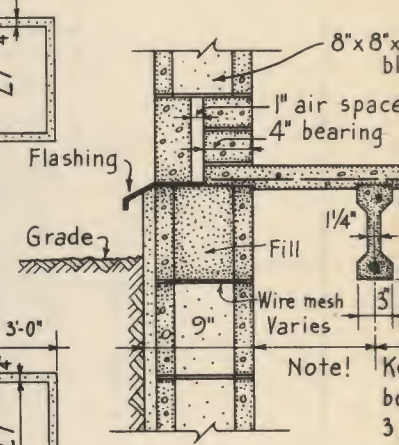


ROOF FRAMING PLAN

These plans based on values given in Design Table I "Safe Superimposed Loads for Precast Joist Concrete Floors" and Design Table II "Stirrup Spacings for Precast Concrete Joists"

JOIST STE

MARK	HEIGHT-WEB	CLEAR SPAN	LENGTH
J1	8" - 1¼"	14'-8"	15'-4"
J2	8" - 1¼"	10'-4"	11'-0"
J3	8" - 1¼"	14'-4"	15'-0"
J4	8" - 1¼"	14'-4"	15'-0"
J5	8" - 1¼"	14'-4"	15'-0"
J6	8" - 1¼"	14'-8"	15'-4"



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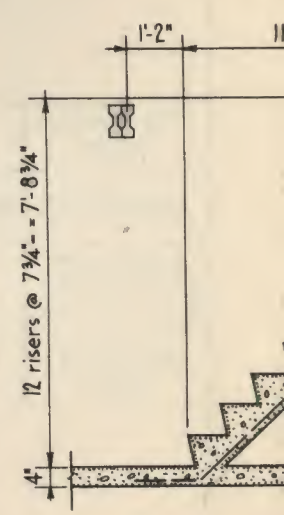
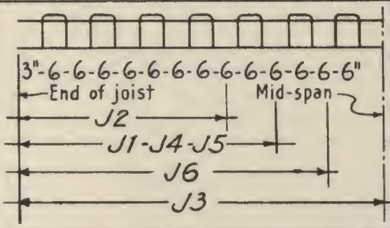


PRECAST JOI

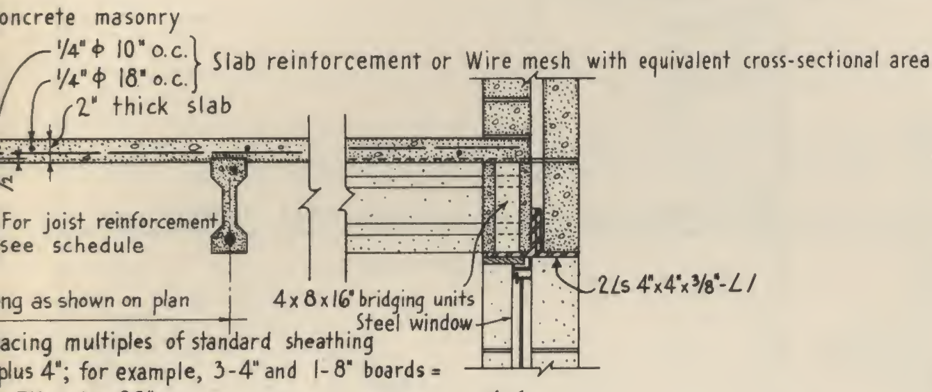
REINFORCEMENT SCHEDULE

...on Bars	Compression Bars	Stirrup Spacing (1/4"φ bars)
3/4"φ	1 - 3/8"φ	
5/8"φ	"	
7/8"φ	"	
3/4"φ	"	
3/4"φ	"	
7/8"φ	"	



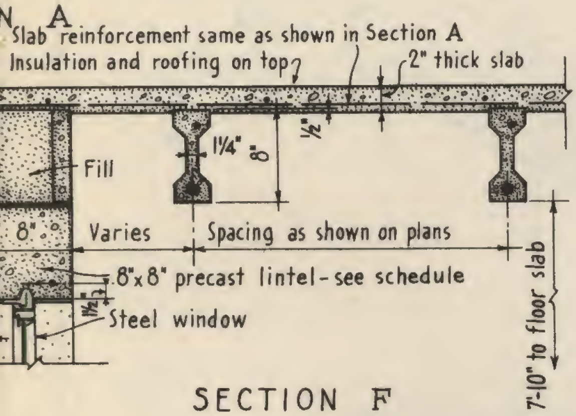
LINTEL SCHEDULE

Mark	Kind	Clear Span	Length	Reinforcement
L1	2Ls 4"x4"x3/8"	4'-6"	5'-2"	See det.
L2	8"x 8" Precast	4'-6"	5'-2"	2 - 3/8" φ
L3	"	3'-4"	4'-0"	"
L4	"	6'-0"	6'-8"	2 - 3/8" φ
L5	"	1'-8"	2'-4"	"
L6	"	2'-10"	3'-6"	2 - 3/8" φ
L7	"	2'-4"	3'-0"	"

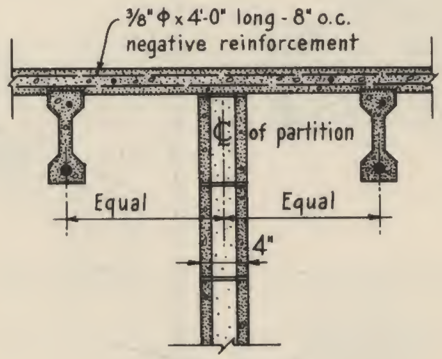


L1

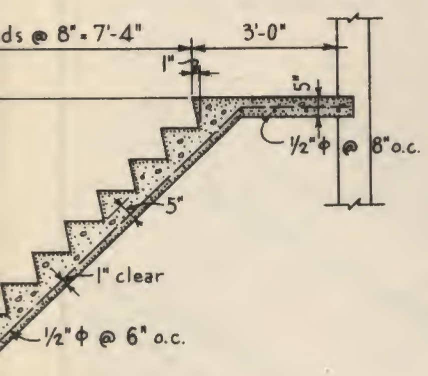
...N A



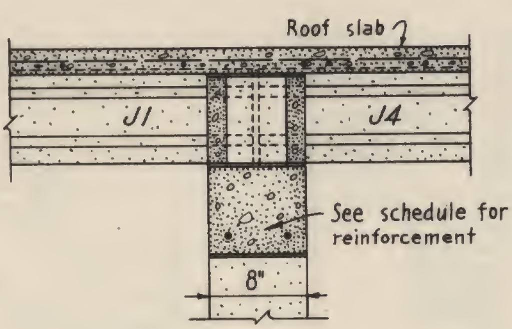
SECTION F



SECTION E

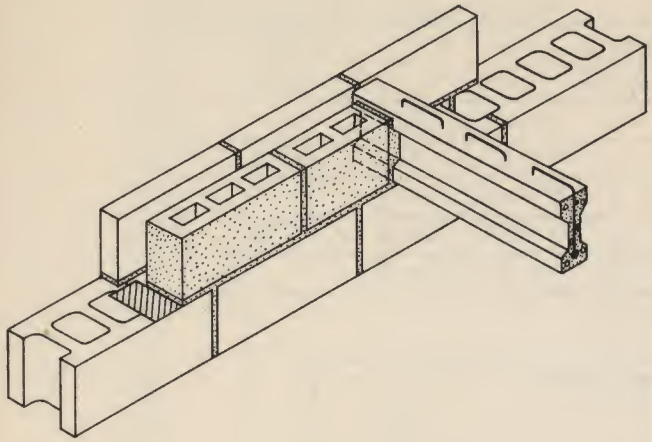


SECTION THRU STAIRS

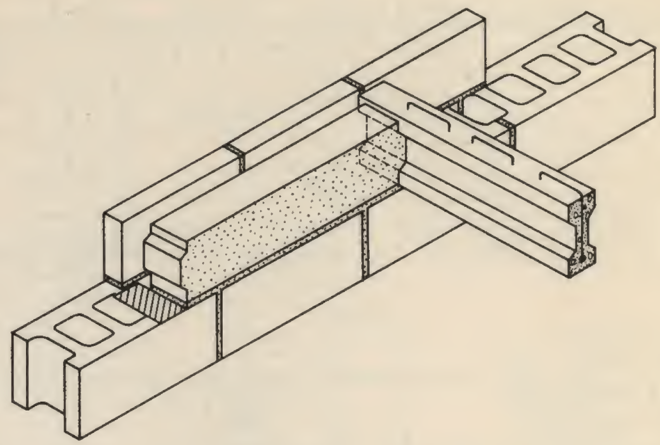


L6 and L7

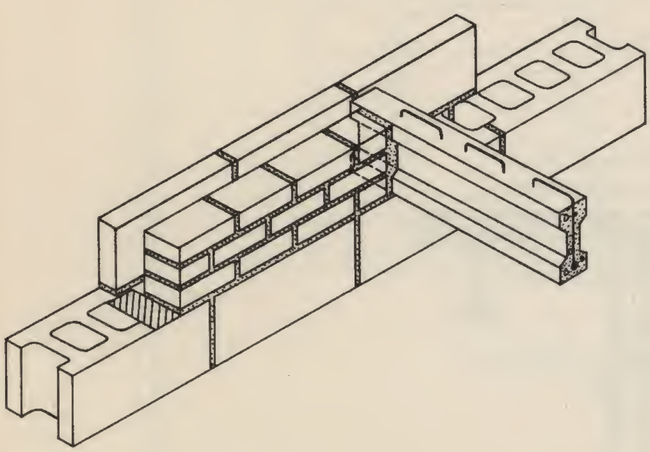
... CONCRETE FLOOR CONSTRUCTION



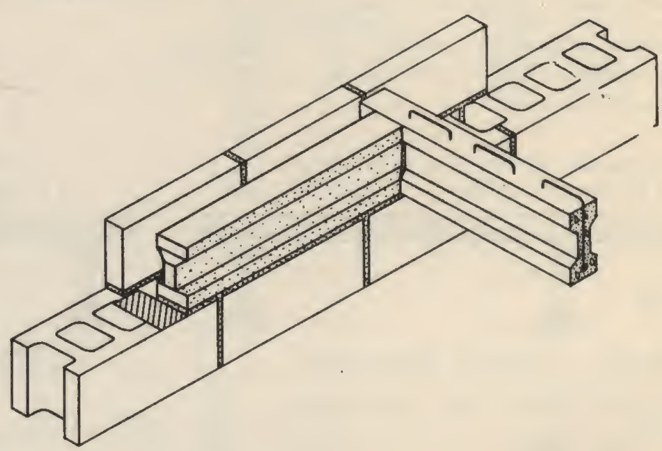
① 4"x8"x16" Concrete Bridging Units



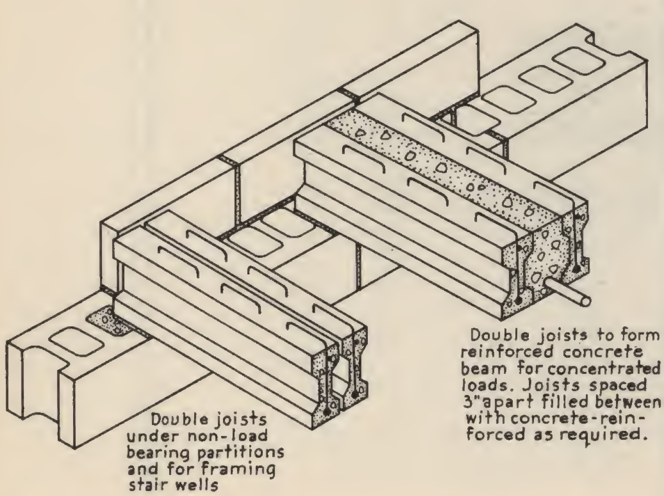
② Precast concrete spacer bridging unit - 4" thick



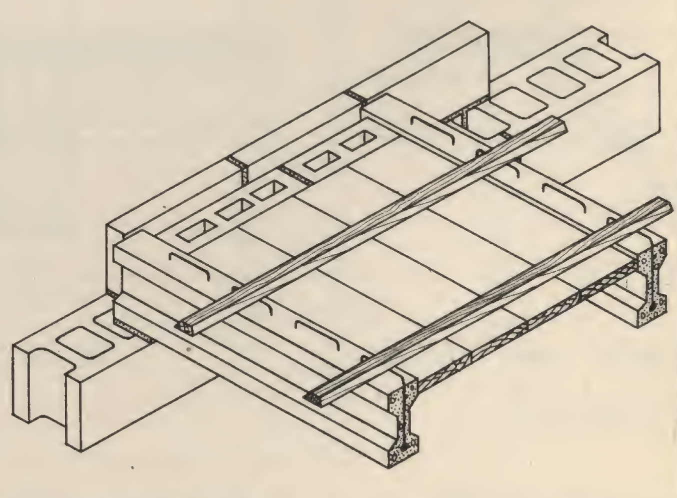
③ Brick bridging



④ Bridging using Joist section



⑤ Methods of framing joist to increase load capacity



⑥ Method of attaching wood nailing strips. Wood strips wired to top of stirrups.

DETAILS - PRECAST JOIST CONCRETE FLOOR CONSTRUCTION

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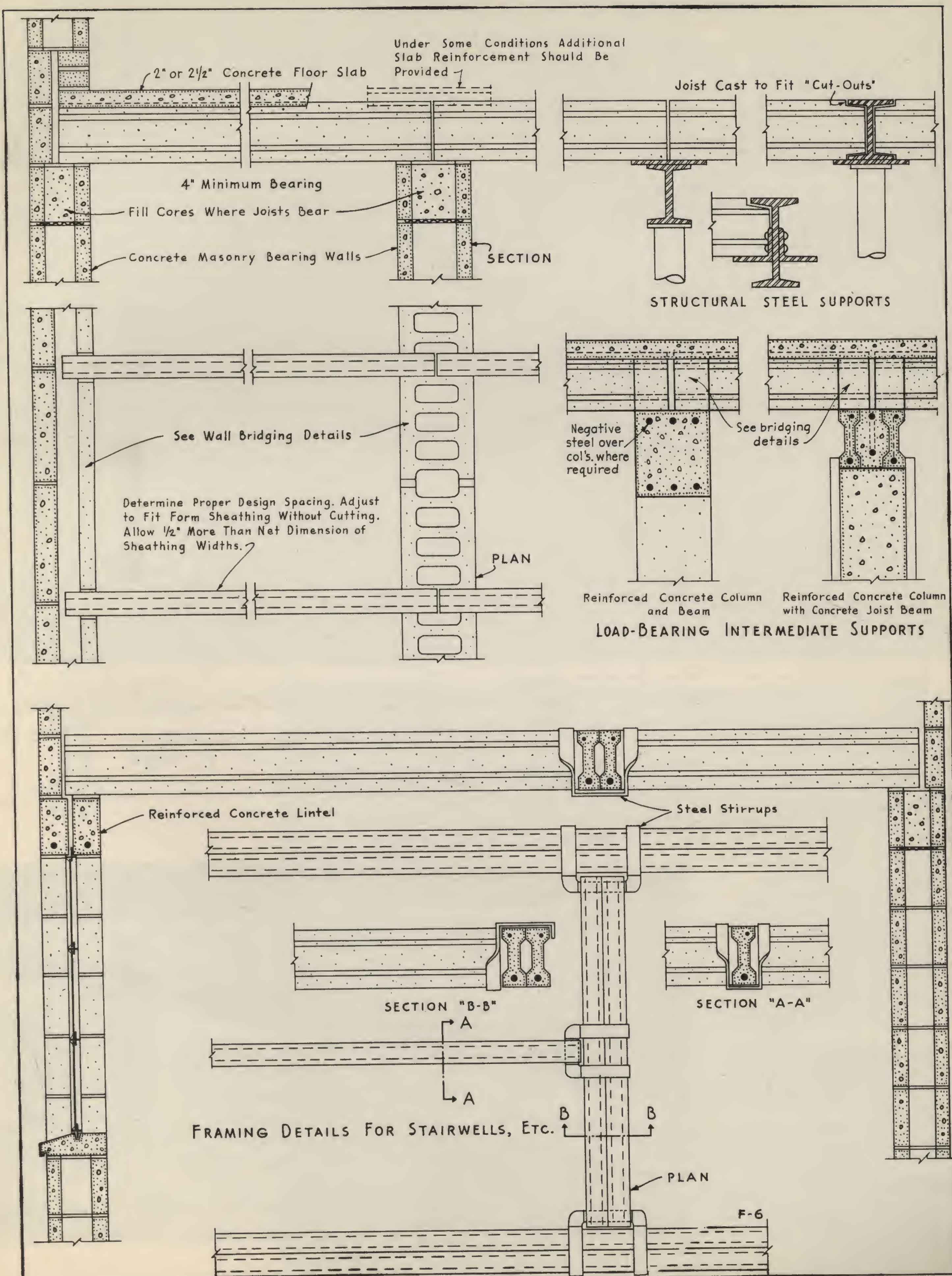
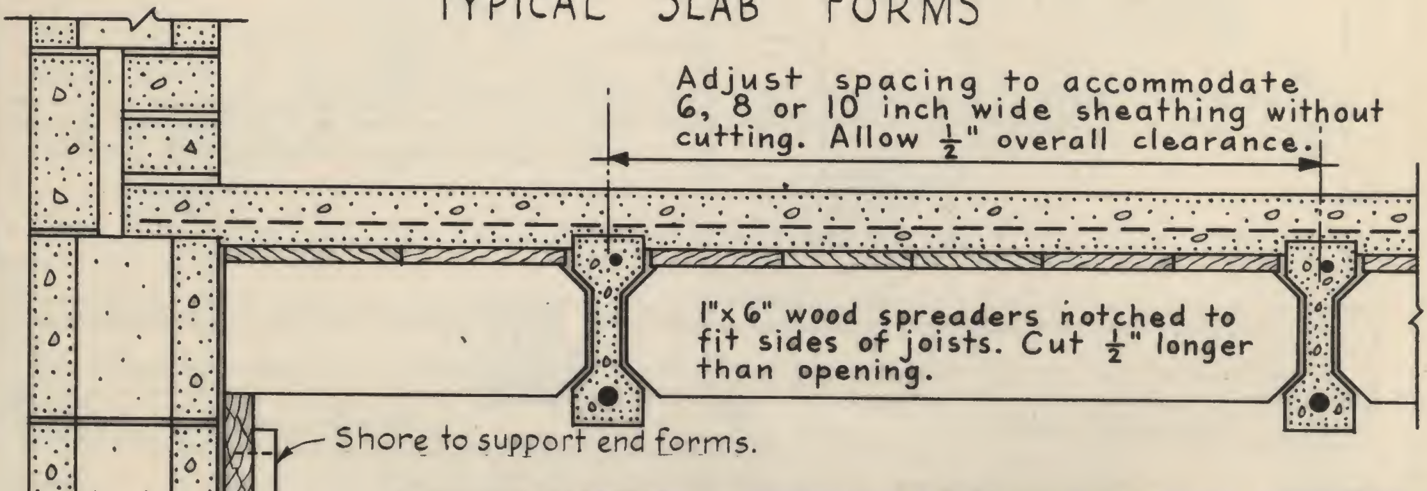


Under Some Conditions Additional Slab Reinforcement Should Be Provided
2" or 2½" Concrete Floor Slab
4" Minimum Bearing
Fill Cores Where Joists Bear
Concrete Masonry Bearing Walls
SECTION
Joist Cast to Fit "Cut-Outs"
STRUCTURAL STEEL SUPPORTS
See Wall Bridging Details
Determine Proper Design Spacing. Adjust to Fit Form Sheathing Without Cutting. Allow ½" More Than Net Dimension of Sheathing Widths.
PLAN
Negative steel over col's. where required
See bridging details
Reinforced Concrete Column and Beam
Reinforced Concrete Column with Concrete Joist Beam
LOAD-BEARING INTERMEDIATE SUPPORTS
Reinforced Concrete Lintel
Steel Stirrups
SECTION "B-B"
SECTION "A-A"
A
A
B
B
FRAMING DETAILS FOR STAIRWELLS, ETC.
PLAN
F-6

TYPICAL SLAB FORMS



Joists in place; spreaders being set

Forms and slab reinforcement in place. Concrete slab being placed.

Concrete Slabs and Precast Joists Act as Monolithic T-Beams

Tests Disclose Large Factor of Safety in Bond Strength Between Slab and Joist—Loading to Failure Caused No Failure in Bond

By F. N. MENEFEE
Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Michigan

FIREPROOF construction and substitutes for wood in home building have received more than the usual amount of attention in the last few years. To those in the building industry who object to the rising costs of wood construction, along with the evils of shrinkage, decay and danger from fire, the results of studies in this field are always interesting.

Generally speaking, the results of a new idea, even when sound, have to be subjected to thorough test and trial. A case in point is the precast reinforced concrete floor joist and the attendant attempt to set it in place and cast a floor slab on top of it with the expectancy of obtaining T-beam action. To begin with, although not new, the precast concrete joist is still somewhat of a shock to the conservative; and yet there are some objections to the monolithic type of construction that the precast beam may avoid.

Joists Prove Value in Actual Service

Regardless of one's ideas as to what is orthodox, the precast beam is being made, cured, and delivered to the job, where it is functioning in accord with accepted principles of mechanics and where monolithic construction would be too expensive due to the cost of forms.

The quantitative shrinkage values of concrete are known; but quantitative values of the grip or the resistance to longitudinal shear of a thin, reinforced floor slab resting on and extending downward for a short distance on each side of the joist, were not known. The following is a résumé of the results of some tests made by the writer to solve the question.

The question resolves itself into one of the resistance to longitudinal movement of the slab relative to the joist. Without a complete bond between the beam and slab, T-beam action would not take place and the benefit of such action would be lost. To determine the efficacy of such construction, joists were set up on representative spans and spacing. Slabs were placed over them and later loaded.

Tests Confirm T-Beam Action

Several floor slab tests were made, some by the writer, others by the building inspectors in Kalamazoo and Grand Rapids, Michigan, and one by H. C. Berry, of the University of Pennsylvania.

Since the tests of the T-beam construction gave load deflection diagrams characteristic of concrete beams and since the loads indicated stresses in steel and concrete in conformity with values to be expected, it seemed reasonable to assume that the laws governing longitudinal shear should apply as well.

Referring to the concrete T-beam shown in Figure 1a, transverse loading of the beam would produce a longitudinal shear across AB and bond stress around ACDB.

The diagram showing variation in shear can be arrived at by the standard mechanics formula for shear stress, but in the case of the concrete beam it is simple to proceed as follows: By summation of horizontal forces, Figure 1b,

$$vbx = T_2 - T_1 \quad \ldots\ldots\ldots \quad (1)$$

v being intensity of longitudinal shear, b the breadth, and

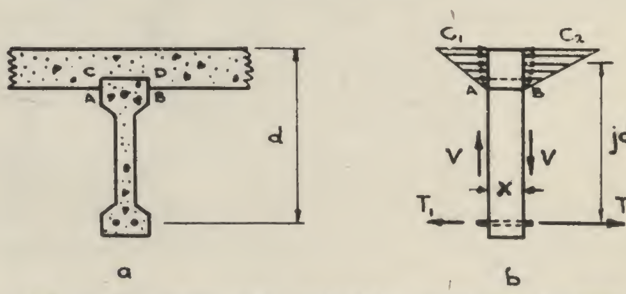


Figure 1. Precast joist, with slab, tested as a T-beam

x the length of the longitudinal portion of the beam under consideration. By summation of moments,

$$Vx = (T_2 - T_1)\, jd = vbxjd$$

$$v = \frac{Vx}{bxjd} = \frac{V}{bjd} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Taking for illustration the value of load per joist as 7,740 lb., width of joist as 3 in. and depth $10\frac{1}{2}$ in., and assuming the neutral axis to be at or near the junction of the slab and joist we get,

$$v = \frac{3{,}870}{3 \times 10\frac{1}{2}} = 123 \text{ lb. per sq. in.}$$

as the intensity of longitudinal shear across AB, Figure 1a. The stress in the joint ACDB will be less than 123 lb. per sq. in., by the ratio of AB to ACDB, or 82 lb. per sq. in. Had the joist been imbedded only $\frac{1}{2}$ in. the latter value would be 92.3 lb. per sq. in.

These values represent the shear at maximum load. The rated total load per beam was 3,400 lb.; hence the bond stress in the joint ACBD at the rated load was $\frac{1{,}700}{3{,}870} \times 82 = 36$ lb. per sq. in., for an imbedment of $\frac{3}{4}$ in., or $\frac{1{,}700}{3{,}870} \times 92.3 = 40.5$ lb. per sq. in., for an imbedment of $\frac{1}{2}$ in.

In a test for the building inspector of Kalamazoo a

panel supported by two beams on a 13 ft. 2 in. span, failed at 20,200 lb. of total load. The total shear at each beam end was 5,050 lb. The maximum unit shear across AB for $jd = 10\frac{1}{2}$ in. was 144 lb. per sq. in., and the probable stress on bond around ACDB (assuming imbedment of $\frac{3}{4}$ in.) was 96 lb. per sq. in.

The rated working load was 8,400 lb. as compared with 20,200 lb. at failure; hence the bond stress at the rated

working load was $\dfrac{8{,}400}{20{,}200} \times 96 = 39.8$ lb. per sq. in.

No Failure in Bond

These two beams are typical of several that have been tested. The computed bond stress at the rated working load was about 40 lb. per sq. in.; that at failure between 90 and 100 lb. per sq. in., although the failure was never one of the bond between the slab and joist.

Variation of the value of jd in the formula for shear will seldom be more than 10 per cent, so that the above values seem to be about what may be expected in this type of construction on spans up to 20 ft.

Large Factor of Safety

In order to get a quantitative value of the bond strength of this molded mortise joint, ACDB, a test specimen was designed (see Figure 2) upon which a load could be placed which would have to be supported through the resistance of the bond between the slab and joist. The slab

Figure 2. Type of specimens used for testing bond strength at failure

portion was reinforced in both directions with two 5/16-in. rods. In some cases the tie rods running from one slab to the other were looped, and in other cases the loops were omitted.

Column 5 of Table 1 shows the resistance, in lb. per sq. in., of each of 14 separate specimens made up for the first test. It will be noted that the lowest value is 269 lb. per sq. in., whereas the computed value of maximum bond stress around ACDB in full sized floor panels was about 100 lb. per sq. in. and the bond stress at working loads was about 40 lb. per sq. in. The factor of safety is greater than that which we demand in concrete work. At later dates, other batches were made up and tested. The

TABLE 1, JANUARY, 1932

Specimen	Age, days	Mix	Cement	Bond resistance at failure, lb. per. sq. in.	Comp. str., lb. per sq. in.
1	16	1:2:3	A	432	
2	13		A	528	
3	28	1:2:4	A	482	1,860
4	28		A	312	1,990
5	28	1:2:4	B	460	1,990
6	28		B	535	1,700
			B		1,770
7[1]	34	1:2½:3	C	606	3,270
8	34		C	547	
9	58		C	650	3,060
10	58			587	
11[2]	38	1:2:4	D	346	685
12	38			269	730
13	38			305	
14[3]	38			350	

[1] This specimen did not fail in bond but by shearing of the pre-cast joist.
[2] 2 lb. calcium chloride per sack of cement.
[3] 4-in. silo tile replacing Lith-I-Bar pre-cast joist.

results are shown in Tables 2, 3 and 4. The values check closely those of Table 1.

TABLE 2, JANUARY, 1933

Specimen	Age, days	Mix	Bond resistance at failure, lb. per sq. in.	Comp str., lb. per sq. in.
1	21	1:1.5:4	360	2,175
2	31	"	327	2,330
3	31	"	310	2,450
4	31	"	180	1,600
5	31	"	295	2,170
6	31	"	301	2,110
TABLE 3, FEBRUARY, 1933				
1	31	1:2:4	276	2,700
2	31	"	196	
3	31	"	562	4,310
4	31	"	522	3,790
5	31	"	338	2,870
6	31	"	355	3,410
TABLE 4, MARCH, 1933				
1	28	1:2:3	530	2,875
2	28	"	501	
3	28	1:2.15:2.85	450	
4	28	"	210	
5	28	"	200	
6	28	"	130	

Additional Tests Contemplated

Because of the surprising results and at the suggestion of H. F. Young, of Kalamazoo, we made up four specimens in which the mortise joint was omitted entirely, the pre-cast joist being cemented to the slabs with a mortar made

TABLE 5, MAY, 1933

Specimen	Mix	Cement	Bond resistance at failure, lb. per sq. in.
1	3 lb. sand	A	99
2	6 lb. cement	A	122
3	0.43 lb. lime	B	230
4	1.55 lb. water	B	216

of 3 lb. cement, 6 lb. sand, 0.43 lb. lime and 1.55 lb. water. Table 5 shows the results.

The writer hopes to carry on more tests on larger size webs and greater thicknesses of slab, but for floor slabs and precast joists of dimensions referred to in the foregoing it is safe to say that with a mortise $\frac{3}{4}$ in. deep, and with concrete that will readily flow around the joist, failure will come somewhere else than in the bond at the junction between slab and joist.

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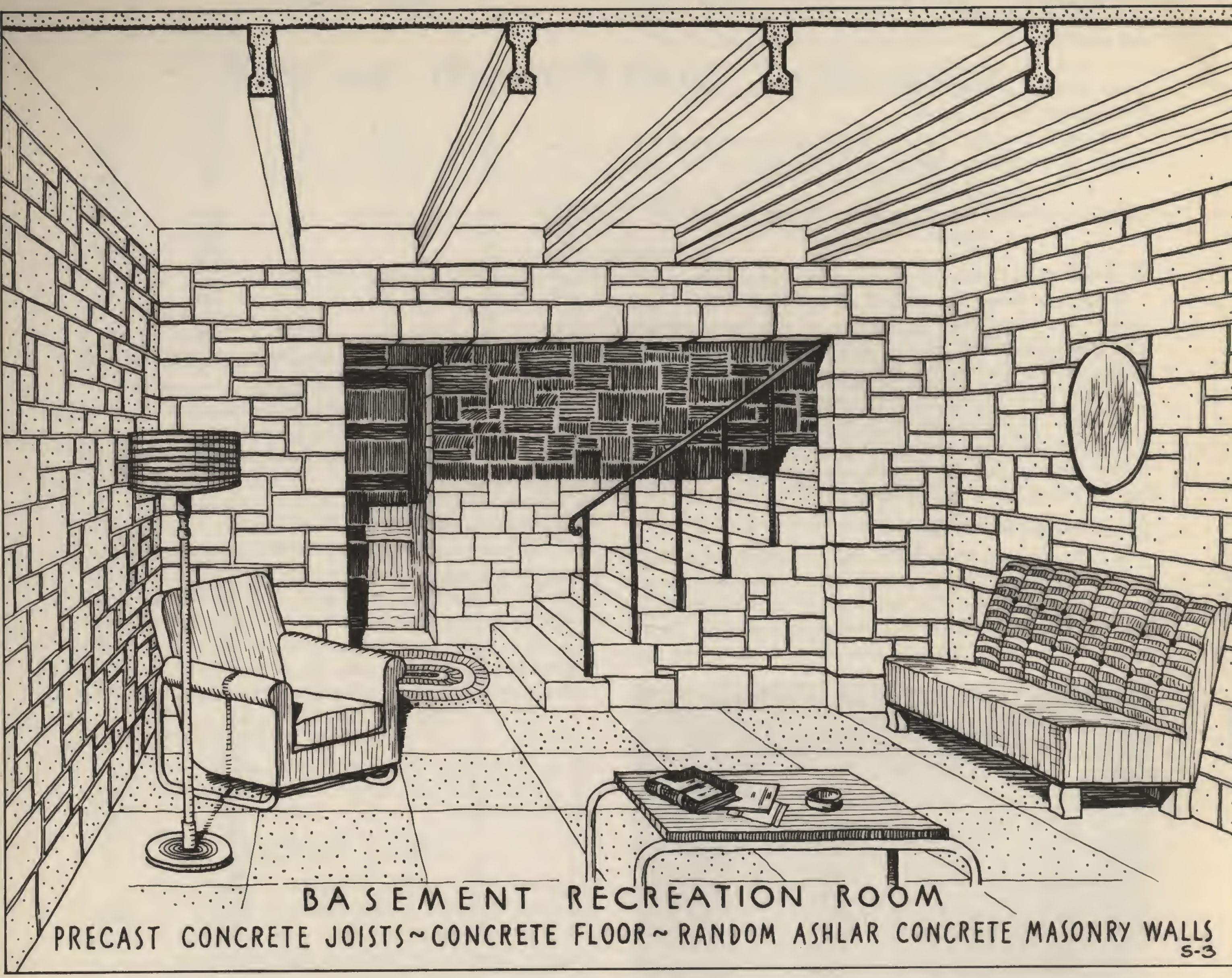

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